

REMARKS

Review and reconsideration on the merits are requested.

Basis for New Claim Amendments

For claim 1, see page 5, lines 17-18, page 7, line 23 to page 8, line 15, page 10, lines 4-12, page 18, lines 20-22 and page 19, line 27 to page 20, line 4.

For claim 4, see page 5, lines 23-26 and page 25, lines 5-9.

For claim 5, see original claim 5 and page 6, lines 5-10.

For claim 6, see original claim 6 and page 6, lines 11-18.

For claim 9, see original claim 5 and page 6, lines 3-5.

The Rejections and the Art

Claims 1-3, 5, 6, 9 and 11-14 under 35 U.S.C. 103(a) as being unpatentable over JP 2001-214212 (JP '212) in view of Floreen (U.S. Pat. No. 4,443,254) and JP-56-090957 (JP '957).

Claims 4, 7, 8 and 10 under 35 U.S.C. 103(a) as being unpatentable over JP '212 in view of Floreen and JP '957 as applied to claims 1, 5, 6 and 9 alone or in further view of Uehara et al. (U.S. Pat. No. 6,767,414 Uehara).

Claims 15 and 16 under 35 U.S.C. §103(a) as being unpatentable over JP '212 in view of Floreen and JP '957 as applied to claims 1, 5, 6 and 9, further in view of Uehara.

Claims 1-3 under 35 U.S.C. 103(a) as being unpatentable over Smith Jr. et al. (U.S. Pat. No. 4,871,511 Smith), and

Claim 4 under 35 U.S.C. 103(a) as being unpatentable over Smith Jr. as applied to claim 1, and further view of Uehara.

The rejections are respectfully traversed for the reasons now set forth.

Applicants focus on the following remarks of the Examiner set forth in the Action of February 26, 2007:

“Therefore, one of ordinary skill in the art would expect the size of inclusions to be substantially the same in JP ‘212 in view of Floreen and JP ‘957 as the instant invention.” (Action, page 3, end of second full paragraph.)

“Therefore, one of ordinary skill in the art would expect the size of inclusions to be substantially the same in Smith Jr. et al as the instant invention.” (Action, page 5, end of first full paragraph.)

Against the above background, Applicants now present their traversal.

Traversal

Brief Comments on the Prior Art

Applicants believe that the prior art can reasonably be characterized in broad overview as follows.

JP ‘212

JP ‘212 provides a Ti-containing steel which contains TiN type inclusions having a length of not more than 10 μm . This is to avoid any deterioration in fatigue durability of the steel.

JP ‘212 solves the “inclusions” problem by using a refining method for TiN type inclusions where a raw material is used for Ti-containing steels which does not contain any TiN type inclusions.

JP ‘212 does not, however, teach or suggest positively refining nitride inclusions and oxides during melt processing, rather, JP ‘212 teaches restraining the growth of TiN inclusions

rather than the concept of performing refining as a positive procedure. See the later discussion at this point.

Floreen

Floreen provides a maraging steel by a procedure which involves conventional melting, VIM, conventional melting+ VAM or VIM+VAM. While Floreen usually uses aluminum for deoxidation, Zr, B, Ca or Mg can also be added in an amount of at most 0.25% for deoxidizing and/or malleabilizing purposes.

JP '957

JP '957 provides a maraging steel of improver systems to stress corrosion cracking. JP '957 proposes adding Mg, Ca and/or a REM. JP '957 is silent regarding refining nitrides and/or oxides in the steel by the use of Mg during vacuum remelting.

Smith

Smith is directed to providing Seal-Premaraging steels which show certain improved characteristics. Smith obtains such a Seal-Premaraging steel by adding Ti and using an aging treatment. Smith can add amounts of up to 0.25% of Ca and/or Mg. Smith uses AOD+VIM+VAR.

Uehara

Uehara contains no teaching on adding Mg in conducting vacuum melting twice. Applicants understand that Uehara is relied upon only for teaching a thickness of about 0.3 mm and use as a component of a continuously variable transmission.

The Present Invention

Background

The Examiner relies on prior art which disclose maraging steels containing Mg and disclosing vacuum remelting process. However, the present invention does not merely relate to such a steel which is produced by the simple addition of Mg during steel production, or a steel in which Mg is merely permitted to remain in the final steel.

The present invention belongs to a particular technical field of producing a Ti-containing maraging steel, and achieves restraining growth of metallic inclusions during melting and solidifying where such growth has been regarded as impossible to avoid. In the case where non-metallic inclusions, especially Ti-type non-metallic inclusions have grown in steel, material fracture is initiated from such non-metallic inclusions. Thus, in the case where the Ti-containing maraging steel is applied to motor vehicle components which involve human safety, it has been a most important problem to restrain the growth of non-metallic inclusions in the Ti-containing maraging steel.

Principle of the Invention

Primary Melting:

A consumable electrode made of the invention steel, containing a predetermined amount of additive Mg, for vacuum arc remelting, is obtained from a molten steel produced by vacuum induction melting (VIM). In this case, it is extremely important for the consumable electrode to contain remaining Mg.

Ti-type non-metallic inclusions (which are essentially TiN) in the metal structures of the consumable electrode with remaining Mg, which Mg is added to the molten steel during vacuum induction melting, can be seen in the attached photograph A which was taken by an SEM (Scanning Electron Microscope). In photograph A, there is shown a generally hexagonal TiN inclusions and a nucleus of MgO in the TiN inclusion. The TiN has been crystallized and grown during solidification of a casting having the form of a consumable electrode.

Secondary melting (i.e., remelting):

The consumable electrode is subjected to vacuum arc remelting (VAR) during which MgO generally disappears and TiN inclusions are refined. The principle involved in this particular step is not entirely clear, but it is believed that Mg which formed the nucleus MgO vaporizes upon heating during VAR under high vacuum, whereby MgO decomposes to promote the decomposition of TiN inclusions, thereby making it possible to prevent the phenomenon that remaining TiN coarsens during solidification. Photograph B shows a TiN inclusions in the metal structure of the invention steel after VAR, wherein MgO, which has been a nucleus, cannot be seen in the TiN inclusion which is general agreement with the above hypothesis.

As can be seen, the **key aspects** of the present invention is to control the amount of Mg during VIM and during VAR processing, whereby one can also control and decrease the oxide-type inclusions.

The Prior Art

It has been known to use Mg when preparing maraging steel.

One example of Mg utilization is for deoxidization. In this case, oxygen is not reduced only by adding Mg into molten steel, but MgO produced by the addition of Mg must be removed from the molten steel. In other words, the remaining MgO in the steel is detrimental from the view point of deoxidization. Thus, the principle of the present invention is basically different from known techniques with utilization of Mg for the purpose of deoxidization, whereas according to the principles of the present invention, MgO formed should remain after VIM processing.

Another example of Mg utilization is to permit Mg to remain in steel in order to improve the steel in workability, for example. In this case, it should be noted that Mg vaporizes easily, so that if the steel is subjected to VAR processing, almost all Mg in the steel will disappear under the vacuum used. Given the fact that the Mg will disappear (evaporate) during VAR processing, quite obviously the use of VAR processing would be inconsistent with achieving the results of workability. In contrast, according to the present invention, it was realized that in order to refine non-metallic inclusions including TiN by decomposing and remove MgO during VAR processing. From the above discussion, it should be clear that the present invention has essentially no relationship with known steel processing where the steel must contain Mg as an indispensable element, i.e., cannot undergo VAR which involves a high vacuum which would result in the loss of Mg.

Rejection of claims 1-3, 5, 6, 9 and 11-14

In JP '212, no Mg is used. Refining of Ti-type non-metallic inclusions is achieved by selecting raw material and not by Mg reaction. JP '212 is silent on refining of oxide type

inclusions. Since the inclusion refining mechanism of JP '212 is different from that of the present invention, the maraging steel as defined in present claim 5 is distinguished from the Ti-containing steel of JP '212 in components.

JP '957 and Floreen

These two references have no relationship to the present invention which is directed to the refining of non-metallic inclusions in steel.

JP '957 teaches that 0.001 to 0.1 wt% of Mg may be optionally added in a maraging steel for the purpose of deoxidization and in order to improve the maraging steel in resistance to stress corrosion cracking.

In Floreen, not more than 1% of Mg may be optionally added to a maraging steel for the deoxidization and to improve malleability. It should be noted that so far as Mg is used for the purpose of deoxidization, the advantages of Mg as in the present invention cannot be obtained in the maraging steels of Floreen.

There is no motivation to add Mg to the Ti-containing steel or maraging steel for other purposes than deoxidization even if JP '957 and/or Floreen is combined with JP '212. This is because there is no suggestion in the prior art that oxides can be refined by VAR processing or that TiN can be refined by the use of Mg.

JP '957 and Floreen

Neither of these references relate to refining of non-metallic inclusions in steel. JP '957 teaches that 0.001 to 0.1 wt% of Mg may be optionally added in a maraging steel for deoxidization and to improve resistance to stress corrosion cracking.

In Floreen, not more than 1% of Mg may be optionally added in a maraging steel for deoxidization and to improve malleability. It should be noted that so far as Mg is used for the purpose of deoxidization, the advantages of Mg in the present invention cannot be obtained in the maraging steel of Floreen.

There is no motivation to add Mg to the Ti-containing steel or maraging steel for other purposes than deoxidization even if JP '957 and/or Floreen is combined with JP '212, **since it has not been known** that oxides can be refined by the VAR process, and that TiN can be refined by Mg.

Rejection of claims 1-3

Smith

Mg is only one example additive element which may be contained in maraging steels. Since it was not known that oxide type and TiN inclusions could be refined by Mg in the VAR process, one of ordinary skill in the art would not be led to the concept of first forming MgO in a Ti-containing maraging steel by adding Mg and thereafter refining non-metallic inclusions by VAR processing.

The Invention

The present invention is based upon an understanding and recognition of the principles of VAR processing as it applies to titanium containing steels and is directed to and based on the use of specified amounts of Mg to control the presence of non-metallic inclusions comprising nitrides having a nucleus of MgO.

It is well known that VAR processing can and will decrease the amount of oxygen present as a gaseous element during dissolution of a steel under a high vacuum. As a consequence, VAR processing can and will improve various mechanical properties.

VAR processing is effective even if a maraging steel containing Ti is being processed. However, a problem results. Specifically, the problem is that TiN inclusions grow to a large size when VAR processing is used.

TiN inclusions are harmful in that they serve as a starting point for a deterioration in fatigue characteristics of the maraging steel. As a consequence, conventional processes for manufacturing maraging steels containing Ti cannot take advantage of the VAR process.

The present invention effects both a decrease in oxygen and controls the non-metallic inclusions comprising nitrides, most especially TiN, and offers the maraging steel production industry substantial and important advantages.¹

TiN Size Comparison

For the situation of Mg free conditions, the following graphically presents the TiN size after VAR vs. the TiN size in an electrode (before VAR).

¹ Applicants have advised that the applications corresponding to the present application have been registered in Japan (JP-3682881-B) and that before the EPO, there are no reasons to base a rejection upon a lack of inventive step (EP 1422301A).



With reference to the TiN size in the electrode before VAR, the Examiner is respectfully requested to refer to the present specification at page 22, lines 2-8 wherein it is stated (bolding added):

In VIM, the raw materials were selected and subjected to vacuum refining. In the same manner as the oxide inclusions, the sizes of carbonitride inclusions of titanium, such as TiCN and TiN, that adversely affect fatigue characteristics of the maraging steel were controlled to be **not more than 10 μm .**

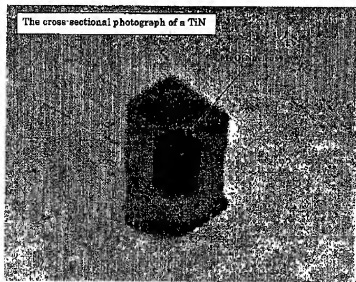
With respect to TiN size after VAR, the Examiner is respectfully requested to refer to Table 4 at page 30, No. 12, where under the heading "Maximum Length of Nitride Inclusions (μm)" the value is given as 10.8 μm .

From Table 4 at page 30, in Conventional (Comparative) Steel No. 12, which is Mg free, the size of the TiN after VIM has grown to be over 10 μm . Referring to the Invention steel values in Table 4, (No. 7-10) the size of the Ti-N after VIM is 10 μm or less, specifically a maximum of 7.2 μm .

Applicants later discuss the 6.1 μm size of Conventional (Comparative) Steel No. 11.

Applicants now address the form of TiN.

The form of TiN after primary melting (at the electrode) is shown below:



Referring now to the specification at page 8, line 27 to page 9, line 5, it is disclosed:

On the other hand, the nitride inclusions such as TiN and TiCN also use **magnesia as the nucleus and finely exist in the consumable electrode.** (Bolding added). Therefore, thermal decomposition of the nitride inclusions is also promoted during the remelting, and, as a result, the refining of the nitride inclusions is achieved.

While not wishing to be bound, Applicants believe that the following discussion provides a hypothetical and probably, but not definitely, correct of how a steel in accordance with the

present invention and how a conventional steel (Mg free) would behave just after the melting of TiN at the primary electrode.

The inventive steel has a TiN exterior surrounding an MgO nucleus. The conventional steel would just have a corresponding exterior of TiN without the MgO nucleus.

The TiN would behave in as follows under VAR processing.

In the inventive steel, $\text{TiN} \rightarrow \text{Ti} + \text{N}$, and Ti and N would dissolve into the electrode. With the conventional steel (Mg free), since there is also TiN present, the same would occur.

However, then there is a large difference.

For purposes of this hypothetical, assume a consumable electrode as the uppermost part (A) in a processing system, and droplets (B) hang from the consumable electrode (A) and some of the droplets (B) fall from the consumable electrode. Below the consumable electrode there is an ingot which has at the top area of the ingot facing the consumable electrode what could be viewed as a concave area which is a pool of liquid metal having, at the very interface of the ingot and the droplets, a pool of liquid metal which has a "mushy" zone (C).

In the Inventive steel, the TiN behaves as follows:



Ti and N dissolve into the liquid metal. Elements in the Inventive molten steel behave as follows:



In the Conventional steel (Mg free) TiN and the elements behave as follows:



The MgO nucleus is also in the state of dissolving into the molten metal in the Inventive steel (there is no Mg in the Conventional steel).

After enough dissolution of TiN occurs so that the MgO nucleus of the Inventive steel is reached, MgO will be gone from the TiN by decomposition of MgO, the TiN and MgO behaving as follows.



Ti, N, Mg and O dissolve in the molten Inventive steel.

Once the elements are in the molten Inventive steel, they behave as follows:



At this stage, the TiN is all dissolved into the Inventive molten metal. Since MgO was present as a nucleus in the TiN, in a sense, the volume of TiN is relatively small. Further, since MgO decomposes or drops out of the TiN as a center or nucleus of the TiN, the surface area of the TiN will be increased once the MgO nucleus is gone and the surface area of the TiN increases so that TiN easily dissolves.

On the other hand, for the Conventional steel (Mg free), there was no MgO nucleus inside the outer "wall" of TiN. As a consequence, TiN and elements still behave as follows in the Conventional molten steel:



In the dissolution of the Conventional steel (Mg free), the amount of TiN becomes smaller, but the TiN does not completely dissolve.

Applicants now address the behavior of TiN and the "mushy" zone (C) under VAR conditions.

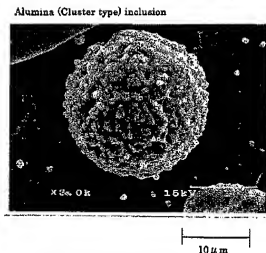
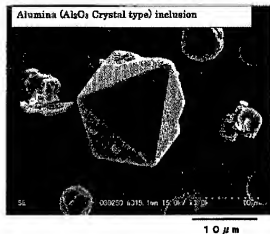
It is believed that TiN will newly form in the "mushy" zone. While the TiN is small at first, it will form in the "mushy" zone and become larger.

On the other hand, with the Conventional steel (Mg free), since TiN was larger to start with (no MgO nucleus dissolved to increase surface area of the TiN), the TiN which is relatively larger begins to grow and further grows. As a consequence, the TiN size becomes larger than at the time that VIM is completed.

Applicants now turn to what happens to Al_2O_3 after the second melting (at the VAR ingot). This is the conventional steel which is Mg free.

The following two photographs represent the oxide after second melting at the VAR ingot:

ventional steel (Mg free) : Oxide after secondly melting (at 7



Referring now to page 15, line 3 to page 16, line 4 of the specification, the following disclosure occurs:

"This is very characteristic in that about 80% of alumina inclusions can be confirmed, when Mg is not positively added at the time of the producing of the consumable electrode, but the spinel form inclusions having a size of 10 μm or more exceeds 33% with respect to the total amount of the spinel form inclusions having a size of 10 μm or more and the

alumina inclusions having a size of 10 μm or more with the application of the producing method of the present invention. The spinel form inclusions having a size of not less than 10 μm is more preferably in a range of not less than 50%, further preferably in a range of not less than 70% (bolding added).

It should be noted that the size of the oxide inclusions is set to not less than 10 μm , because the non-metallic inclusions having this range of size have a possibility that the fatigue strength is especially influenced. Moreover, it is difficult to exactly confirm the number of excessively small non-metallic inclusions.

It should be noted that the alumina inclusions mentioned in the present invention indicate such non-metallic inclusions that an oxygen (O) peak is mainly detected in gas components constituting the non-metallic inclusions, for example, as shown in Figs. 3, 4 at the time of qualitative/quantitative analysis of the non-metallic inclusions in a structure by an energy dispersed type X-ray analysis device (EDX), and Al occupies not less than 85 mass% in the detected elements other than oxygen (O).” (bolding added)

Referring now to Tables 4 and 5, data from those tables are set forth below.

Table 4

No.	Electrode nitrogen (ppm)	Rate of 10 μ m or more spinel form inclusions	Rate of 10 μ m or more alumina inclusions	Maximum length of oxide inclusions (μ m)	Maximum length of nitride inclusions (μ m)	Remarks
7	5	100%	0%	13.8	3.3	Invention steel
8	5	92.0%	8.0%	17.2	4.3	Invention steel
9	10	100%	0%	13.1	6.7	Invention steel
10	10	100%	0%	12.5	7.2	Invention steel
11	5	22.0%	78.0%	22.4	6.1	Comparative steel
12	10	30.5%	69.5%	24.7	10.8	Comparative steel

Table 5

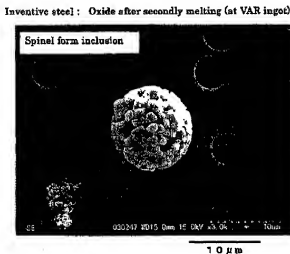
No.	Electrode nitrogen (ppm)	Rate of 10 μ m or more spinel form inclusions	Rate of 10 μ m or more alumina inclusions	Maximum length of oxide inclusions (μ m)	Maximum length of nitride inclusions (μ m)	Remarks
7	5	100%	0%	11.0	3.4	Invention steel
8	5	85%	15%	14.1	4.3	Invention steel
9	10	100%	0%	9.8	6.8	Invention steel
10	10	100%	0%	10.6	7.1	Invention steel
11	5	15%	85%	21.6	6.2	Comparative steel
12	10	21%	79%	23.2	10.7	Comparative steel

Referring now to the specification at page 30, line 1 to page 30, line 5, the following disclosure occurs:

"It is seen from Table 5 that concerning oxide, when the Mg content of the consumable electrode exceeds 5 ppm in the same manner as in the check results of Nos. 1 to 6 shown in Table 3, the oxide inclusions exceeding a size of 20 μ m are eliminated in the maraging steel strip. Most of the oxide inclusions other than the alumina inclusions having a size of not less

than 10 μm in Table 3 is the spinel form inclusions and MgO . In the comparative examples, the alumina inclusions are mainly contained.” (Bolding added).

Applicants have provided the following photograph regarding the Inventive steel which shows the oxide after second melting at the VAR ingot.



The Examiner is requested to refer to the specification at page 16, lines 5-11 where the following disclosure occurs:

“Furthermore, the spinel form inclusions indicate such non-metallic inclusions that the oxygen (O) peak is mainly detected in the gas components constituting the non-metallic inclusions, for example, as shown in Figs. 1, 2, the content of Al is less than 85 mass% in the detected elements other than O, and Mg is detected.”

Applicants again reproduce Tables 4 and 5 from the specification with somewhat different bolding for emphasis.

Table 4

No.	Electrode nitrogen (ppm)	Rate of 10 μm or more spinel form inclusions	Rate of 10 μm or more alumina inclusions	Maximum length of oxide inclusions (μm)	Maximum length of nitride inclusions (μm)	Remarks
7	5	100%	0%	13.8	3.3	Invention steel
8	5	92.0%	8.0%	17.2	4.3	Invention steel
9	10	100%	0%	13.1	6.7	Invention steel
10	10	100%	0%	12.5	7.2	Invention steel
11	5	22.0%	78.0%	22.4	6.1	Comparative steel
12	10	30.5%	69.5%	24.7	10.8	Comparative steel

Table 5

No.	Electrode nitrogen (ppm)	Rate of 10 μm or more spinel form inclusions	Rate of 10 μm or more alumina inclusions	Maximum length of oxide inclusions (μm)	Maximum length of nitride inclusions (μm)	Remarks
7	5	100%	0%	11.0	3.4	Invention steel
8	5	85.0%	15%	14.1	4.3	Invention steel
9	10	100%	0%	9.8	6.8	Invention steel
10	10	100%	0%	10.6	7.1	Invention steel
11	5	15.0%	85%	21.6	6.2	Comparative steel
12	10	21%	79%	23.2	10.7	Comparative steel

The Examiner's attention is directed in this regard to page 30, line 1 to page 31, line 5:

"It is seen from Table 5 that concerning oxide, when the Mg content of the consumable electrode exceeds 5 ppm in the same manner as in the check results of Nos. 1 to 6 shown in Table 3, the oxide inclusions exceeding a size of 20 μm are eliminated in the maraging steel strip. **Most of the oxide inclusions other than the alumina inclusions having a size of not less than 10 μm in Table 3 is the spinel form inclusions and MgO.** In the comparative examples, the alumina inclusions are mainly contained." (Bolding added).

The 6.1 μm of No. 11

Applicants now discuss this point which was earlier mentioned.

First, the Examiner is requested to review Tables 4 and 5 on page 30 and to consider the disclosure at page 28, line 13 to the bottom line on page 29.

Table 4 was prepared based on the specimens taken from ingots after VIM.

Table 5 was prepared based on specimens taking from strips after VAR.

With respect to the "maximum length of nitride inclusions (μm)", comparing Tables 4 and 5, it can be seen that the size of the nitrides does not change so much before and after VAR.

Applicants believe, however, it is proper to compare the nitride size of 6.1 μm of Comparative steel No. 11 (Table 4 on page 30 of the specification) with Invention specimen Nos. 7 and 8, which are 3.3 μm and 4.3 μm , respectively, because they all have the same nitrogen content (0.0005 mass%). See, in this regard, Table 1 on page 24 of the specification.

On the other hand, it would also, Applicants believe, be proper to compare the nitride size of 10.8 μm of Comparative steel No. 12 in Table 4 on page 30 of the specification with that of Invention specimen No. 10, which is 7.2 μm , because they have the same nitrogen content (0.0010 mass%); see Table 1 on page 24 of the specification.

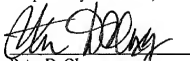
Withdrawal of all rejections is requested.

AMENDMENT UNDER 37 C.F.R. § 1.114(c)
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The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

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